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The Utilization of Food Elements by Growing Chicks. I. A Comparison of Protein Concentrates from Animal and Vegetable Sources

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SUMMARY

1. The effects of adding to a basal ration, protein concentrates from animal and vegetable sources were studied by means of growth and body-analysis experiments.

2. There was a small increase in the nitrogen content of the chicks fed the animal protein concentrate, but no differences appeared between lots with respect to their content of calcium and phosphorus.

3. The percentage rate of gain and the gain per gram of nitrogen fed were greater in the lot fed the animal protein concentrate.

4. The lot fed the animal protein concentrate retained more of the nitrogen fed, but less of the calcium and phosphorus fed than did the lot fed vegetable protein concentrate.

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Several factors account for the interest shown by investigators in the choice of protein concentrates, or combinations of concentrates, in preparing rations for growing chicks. Cost is of prime importance, and for this reason many projects have been undertaken to decide the most profitable plane of feeding such products as meat and fish meals, powdered milk products, soybean, linseed, and cottonseed meals, when the base of the ration is made up of mixtures of the cereals. One of the earlier concepts of the feeding problem was that economy of nutrition was dependent on the proper adjustment between the amounts of protein and total energy supplied by the ration. This concept was modified in later years when emphasis began to be placed on the quality as well as the quantity of protein fed. Wheeler (1) concluded that a ration supplying 40 per cent of the protein as animal protein was more profitably fed to chicks than another ration containing an equal amount of protein mostly from vegetable sources but supplemented with skim-milk curd. In a later publication (2) he stated that more food of a ration of vegetable origin was needed to produce one pound of gain than when a ration containing animal protein was fed. Kempster (3) found that feeding meat scrap, tankage, or milk products reduced the amount of feed required to produce a pound of eggs nearly one-half. In work with rations for laying hens Martin (4) found meat scraps, whole skim milk, and condensed and dried buttermilk profitable additions to the mash.

The object of the experiment to be reported in this paper was to observe variations in the retention of nitrogen, calcium, and phosphorus by growing chicks on two rations differing in the source of the protein concentrate. The general procedure in planning and executing the details of the work was identical with the plan used in previous work (5,6). Conclusions were based on food intake and body-growth data, which coupled with carcass-analysis figures permitted the calculation of the percentage retention of nitrogen, calcium, and phosphorus. The chicks were brooded in electrically heated, metal battery brooders equipped with one-half-inch mesh wire bottoms, through which the droppings passed readily. The minimum temperature in the room during the experiment was 70° F., and the brooders had heat furnished them so that their temperatures were at all times above the critical temperature of chicks, so no complications in the interpretation of data could be attributed to this source. The chicks were hand-fed the pelleted rations so that quantitative individual food intakes were obtained.

PREPARATION OF THE RATIONS

The base of the two rations was identical, and was similar to that in use at this station at the time the experimental work was carried on. The complete rations were prepared by taking 85 pounds of the base and mixing

with 15 pounds of a mixture of animal proteins in the An-X ration, and 15 pounds of the vegetable proteins to make the Veg-X ration. The rations were mixed as follows:

Ingredients	An-X Ration	Veg-X Ration
	Lbs.	*Lbs.*
Yellow corn meal	32.0	32.0
Shorts	20.0	20.0
Bran	10.0	10.0
Pulverized oats	10.0	10.0
Alfalfa meal	10.0	10.0
Ground limestone	2.0	2.0
Sodium chloride	1.0	1.0
Dried buttermilk	4.5	...
Fish meal	4.5	...
Meat scraps	4.5	...
Corn starch	1.5	...
Soybean meal	...	7.5
Corn gluten meal	...	3.38
Wheat gluten meal	...	3.38
Tricalcium phosphate	...	0.75

The ingredients to form the base were ground and mixed, and then one portion was mixed with the animal and the other with the vegetable protein concentrate in a mechanical agitator. Each feed was then pelleted, using a 5/32-inch die. Analysis of the two feeds at intervals during the feeding trial showed but slight variations so that no question arose as to the uniformity of the rations throughout the the experiment. Cod-liver oil was fed by pipette in amounts sufficient to prevent rickets.

The protein content of the two rations was within 0.2 per cent of being identical. About 42 per cent of the protein was furnished by the concentrate in the rations, the other 58 per cent coming from the base. The experimental variable was therefore the source of the proteins constituting the concentrate portion of the rations. The composition of the rations as determined by the method of the A. O. A. C. is given in Table 1.

TABLE 1.—*Analysis of the rations.*

Ration	Water	Ash	Nitrogen	Calcium	Phosphorus	Crude fat	Crude fiber	Protein	N-free extract	Ratio Ca:P
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
An-x	9.2	7.0	2.97	1.47	0.78	3.4	5.7	18.6	56.1	1.88
Veg-x	9.1	6.3	3.01	1.21	0.67	3.0	6.4	18.8	56.4	1.81

EXPERIMENTAL FEEDING

The chicks used were newly hatched White Rocks, chosen at a weight of 37±2 grams. Thirty were leg banded and divided into two lots of 15 each, one lot being assigned to each ration. Because of casualties there were ten survivors in each lot. The chicks were separated by lots in two brooders. The handling of the birds, records kept, analytical methods used, and the manner of hand-feeding the chicks have been described in detail in earlier work (5,6) and need not be gone over in detail in this report.

However, in this experiment the amount of feed given each bird of the two lots was kept the same for each day. That is, all the birds, on any given day, received the same weight of feed, the daily portion being measured out individually from diet bottles assigned to each, and hand-fed to the chicks. This resulted in all ten chicks from each lot receiving identical amounts of feed daily. The matter of an equitable basis for comparing unlike rations has been studied extensively in late years. We have for instance the opinion of Mitchell and Beadles (7) who state that "If one ration is superior to an-

other in the support of an animal function such as growth, its superiority should be evident when the intake of both rations by comparable animals is the same, either absolutely or in proportion to some determinant of food requirements, such as body weight, or a mathematical function of body weight." McClure, Voris, and Forbes (8) feel that "conclusions as to the effects of dietary deficiencies, based on growth data alone, are often compromised as a result of differences in food intake." Crampton and Hopkins (9) agree when they conclude that "From the standpoint of the clarity of interpretation of results, an ideal feeding trial intended to evaluate feeds or rations would be one in which all the animals were alike at the start and consumed equal quantities of feed during the test." It is felt that our combination of hand feeding identical amounts of feed to newly hatched chicks approaches this standard of experimental procedure. However, another slightly different interpretation is given to the question of feed intake in paired feeding experiments by Swift, Kahlenberg, Voris, and Forbes (10) when they say, "It seems not to be possible to compare two diets on a perfectly equitable quantitative basis unless both are mutually complete and perfect." Acceptance of this view implies that when two diets are compared and the response is found to be identical in both lots, an equitable basis for comparison exists. If, however, the response is not identical, it must mean that in one respect, at least, the diet is neither complete nor perfect, and that no equitable quantitative basis for comparison exists. To reach such a basis there are but two alternatives. In the one case the poorer diet must be enhanced to come up to the standard of the better, or the latter must be brought to the level of the former. It seems obvious that the practical needs of the case have been met if the one diet produces results which can be judged superior to those produced by another diet, differing in but one respect from the former.

The criteria on which the conclusions reached in this experiment depend are growth data secured on chicks fed identical amounts of feed and comparative slaughter experiments involving the determination of the nitrogen, calcium, and phosphorus of samples of the feed fed, and on the body at slaughter. The content of nitrogen, calcium, and phosphorus of the newly hatched chicks at the beginning of the experiment was estimated on the basis of data reported in an earlier paper (5). The chicks were analyzed in groups of two or three of like sex from each lot in the manner noted in the second paper of this series (6) and the gains of the constituents computed by comparison of these data with those referred to above. At this time the analytical procedure for calcium and phosphorus was changed by using a combination of nitric and perchloric acids instead of nitric acid alone for the digestion of the sample. A more rapid and effective digestion was obtained by this means.

The chicks in this experiment were fed from January 11 to March 12, or 60 days, during which time each chick was fed 954 grams of dry matter. At the end of the period all were killed by asphyxiation, after food had been withheld for 16 hours. The intestinal tract was removed and emptied, and the nitrogen of the contents of the proventriculus and gizzard deter-

mined and deducted from the ingested nitrogen as a correction. The sex of each chick was confirmed at this time. The records of the growth period included the individual initial weight, final live weight, net body weight, and weights on the days when 150 grams of air-dry feed had been consumed. The last record permits a study of the incremental gains, and of the rates of gain at six different periods during the experiment. Table 2 shows that the lot fed the ration supplemented with the animal concentrate made slightly greater gains than the vegetable-protein-concentrate lot. The gains of the chicks on successive increments of dry matter and the gains for the periods show the progressive decreases noted in the growth rates of all immature animals.

TABLE 2.—*Rates of gain of chicks.*

RATES OF GAIN ON SUCCESSIVE INCREMENTS OF DRY MATTER							
Dry matter increment (*g.*)	136	127	146	136	137	136	136
ANIMAL-CONCENTRATE LOT							
5 males—rate of gain (*p. ct.*)	46	49	51	37	31	46	23
5 females—rate of gain (*p. ct.*)	46	46	45	42	25	42	20
VEGETABLE-CONCENTRATE LOT							
4 males—rate of gain (*p. ct.*)	44	43	44	37	29	43	18
6 females—rate of gain (*p. ct.*)	46	40	42	43	20	41	22
RATES OF GAIN OF CHICKS, CALCULATED AT ATTAINED WEIGHT ON GAIN OVER INITIAL WEIGHT							
Total dry matter fed (*g.*)	136	263	409	545	682	818	954
ANIMAL-CONCENTRATE LOT							
5 males—rate of gain (*p. ct.*)	46	48	49	46	43	43	40[1]
5 females—rate of gain (*p. ct.*)	46	46	45	45	41	41	38[1]
VEGETABLE-CONCENTRATE LOT							
4 males—rate of gain (*p. ct.*)	44	43	44	42	39	40	37[1]
6 females—rate of gain (*p. ct.*)	46	43	42	42	38	38	36[1]

[1] These values differ from the ones in Table 4, since the latter are based on the net weight and these on the live weight figures.

The time necessarily devoted to hand feeding the chicks limits the number of chicks in each lot but Table 3 indicates that this loss is offset by the lower variability resulting from this type of control. Even with but ten chicks per lot and with four males and six females in one lot and five of each sex in the other, the standard errors of the mean net weights of the

TABLE 3.—*Mean net weights*[1] *at slaughter and their standard errors.*

Lot	Males	Females	Males and females (unweighted mean)
	g.	*g.*	*g.*
Vegetable concentrate	372.25±8.96	363.67±7.31	367.96±5.78
Animal concentrate	408.60±8.02	389.20±8.02	398.90±5.66

[1] The net weight is the weight of the chick after removal of the contents of the digestive tract.

males and females in each lot are lower than values usually obtained in lots containing several times as many birds.

The growth data and analytical results secured in this study were handled in the same manner as in previous work (5,6) but the tabular data have been condensed to the summary of the pertinent figures shown in Table 4. In this table figures have been rounded off to two decimal places in the case of percentages of elements in chicks or gains, and to one place in the other figures, such as the calculated retention of the elements. Table 4 shows the composition of the chicks and gains at slaughter weights close to 400 grams. Each chick of the two lots was fed 1,050 grams of air-dry feed which had a dry matter content of 954 grams. The amounts of nitrogen, calcium, and phosphorus fed were calculated from the data of Table 1. The amounts of the elements in the chicks were determined analytically, and the amounts in the gains estimated from data given in the original reports applied to the analyses at slaughter. The percentage retention of the elements was calculated for each sex of the two lots.

CONCLUSIONS

The rate of gain of the chicks fed the ration containing the animal-protein concentrate was eight per cent greater than that of the chicks fed the ration supplemented with the vegetable protein concentrate.

TABLE 4.—*Summary of growth and analytical data on chicks.*

Item	Vegetable concentrate		Animal concentrate	
	Male	Female	Male	Female
No. of chicks	4	6	5	5
Net weight (*g.*)	372	364	409	384
Gain in weight (*g.*)	335	327	371	346
Dry matter fed (*g.*)	954	954	954	954
Rate of gain (*p. ct.*)	35.1	34.3	38.9	36.3
Gain per g. nitrogen fed (*g.*)	10.6	10.3	11.9	11.1
Nitrogen in chicks (*p. ct.*)	3.31	3.27	3.47	3.46
Calcium in chicks (*p. ct.*)	1.16	1.07	1.11	1.05
Phosphorus in chicks (*p. ct.*)	0.76	0.71	0.68	0.73
Ratio, Ca:P in chicks	1.53	1.50	1.63	1.43
Nitrogen in gain (*p. ct.*)	3.39	3.35	3.57	3.55
Calcium in gain (*p. ct.*)	1.24	1.14	1.18	1.12
Phosphorus in gain (*p. ct.*)	0.82	0.75	0.72	0.78
Ratio, Ca:P in gain	1.51	1.53	1.64	1.44
Ether extract (*p. ct.*)	3.9	5.2	3.3	4.5
Nitrogen intake (*g.*)	126.4	189.6	155.8	155.9
Nitrogen in gain (*g.*)	45.2	65.6	66.2	61.5
Nitrogen retained (*p. ct.*)	**35.9**	**34.6**	**42.5**	**39.4**
Calcium intake (*g.*)	50.8	76.2	77.3	77.3
Calcium in gain (*g.*)	16.6	22.4	21.9	19.4
Calcium retained (*p. ct.*)	**32.7**	**29.5**	**29.3**	**25.1**
Phosphorus intake (*g.*)	28.1	42.1	41.1	41.1
Phosphorus in gain (*g.*)	10.9	14.8	14.2	12.8
Phosphorus retained (*p. ct.*)	**39.0**	**35.1**	**34.5**	**31.1**

The lot fed the animal protein retained about 15 per cent more of the ingested nitrogen than did the lot on vegetable protein.

The lot fed the vegetable-protein concentrate retained more of the calcium and phosphorus fed than did the other lot. The differences which appeared cannot be ascribed to the influence of the concentrate, as in the mixing of the concentrates the calcium and phosphorus contents of the mixed feeds were higher in the animal-concentrate ration, and corrections were not made to bring them to the same level. In earlier work (6) the retention of calcium appeared to be determined in part by the percentage of the element in the ration.

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